

## **EFFECTS OF BINAURAL-BEAT STIMULATION ON RECOVERY FOLLOWING TRAUMATIC BRAIN INJURY: A PILOT STUDY**

*by Signe Klepp, OT*

### **Abstract**

Patients suffering from traumatic brain injury (TBI) lose the ability to structure their own life. Rehabilitation is expensive in time, money, and effort. A noninvasive, patient-controlled method, binaural-beat auditory stimulation, may elicit changes in states of consciousness and mood. This study assesses the feasibility and efficacy of using this method to improve self-esteem, quality of life, and function of daily living for persons suffering from old TBI.

### **Introduction**

Traumatic brain injury (TBI) results in the need for lifelong rehabilitation because of loss of memory, reduced ability to concentrate, reduced ability to organize and plan, and lack of initiative. The interventions we have today are helping patients to structure their lives and to rehabilitate themselves cognitively. These methods are expensive in time, money, and effort.

This investigator has worked with TBI in post-acute recovery and long-term rehabilitation since 1995, experiencing fully the challenges of cognitive rehabilitation and the expenses related to effort, time, and cost. This work has identified a need for noninvasive adjunctive interventions that are less expensive, controlled by the client, and perceived as helpful by the client.

The Monroe Institute in Faber, Virginia, has developed a technology with binaural auditory beats embedded in music that research suggests may elicit changes in states of consciousness and mood. [1, 2, 3, 4, 5, 6] There are no known rigorous scientific projects in the field of traumatic brain injury, but anecdotal evidence exists. [7, 8]

Using sound for healing dates from man's earliest records. Available today are specially created music tapes and CDs (Hemi-Sync®) that have binaural beats embedded to produce an auditory brain-stem response. The binaural beats are generated when two tones of slightly different frequencies are presented simultaneously, one in each ear, preferably through headphones. It is hypothesized that the brain integrates the two signals to produce a third sound referred to as a binaural beat.

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headphones. It is hypothesized that the brain integrates the two signals to produce a third sound referred to as a binaural beat.

## **Anecdotal Evidence**

*Case A:* In the autumn of 2000, a Hemi-Sync MIND FOOD® *Concentration* CD was given to a young man, age twenty, in the rehabilitation ward of the hospital. He listened to it daily for a period. He suffered from TBI after a traffic accident. After being released from the hospital several months later, he completed his studies (basic computer science) according to schedule, within seven months after hospitalization he got through the exam, and he has now entered new studies. He is the only person the investigator knows who has completed school and continued to study after a serious TBI. The going was rough, but he made it and is still making it.

*Case B:* A male pensioner, age seventy-six, suffered a fall and eventually moved home to his wife after being hospitalized. He was unable to take any initiative and needed instructions to carry out most tasks of daily living. Even making coffee was a challenge for many months. He was released from the hospital in the summer, and during the winter his wife administered daily listening to METAMUSIC® *Baroque Garden* for a period of three months. During and after this listening period he started to read history books again (he remembered nothing, but he still enjoyed reading). He started solving simple crossword puzzles again, he was able to be on his own for a few hours, and he could go shopping for a few items on his own. This recovery might have happened without Hemi-Sync; we do not know.

## **Materials and Methods**

This is a qualitative study. Because of the small number of participants the results will not be used statistically. Only pre-post measures are compared for each individual respectively.

## **Instruments**

The following instruments were used:

### *Assessment of Motor and Process Skills (AMPS)*

This is a performance evaluation of functioning in activities of daily living (ADL). AMPS<sup>[9]</sup> is used to determine how the client's ADL motor and ADL process (organizational/adaptive) capabilities affect the ability to perform functional daily living tasks safely, efficiently, and independently. The AMPS Graphic Report provides an ADL motor and ADL process ability measure, which monitors ability changes in the client. The cutoff value equals the function of a normal, self-sufficient adult. Values under cutoff on motor skills mean increased effort. Values

under cutoff on process skills mean decreased efficiency, safety, and/or independence. The computer-generated AMPS Graphic Report is interpreted as follows:

Improvements of at least 0.5 logits [a measurement specific to the AMPS instrument] between Test 1 and Test 2 on either AMPS motor or process skill scale indicate that the client's ADL motor or ADL process ability has changed to a degree that has clinical and statistical meaning (i.e., improved occupational performance).

Improvements of 0.3 or 0.4 logits between Test 1 and Test 2 may not be statistically significant, but may still be clinically meaningful in terms of improved occupational performance.

#### *Short Form 36 Health Survey (SF-36)*

This is a health-related quality-of-life measure. SF-36<sup>[10]</sup> is a generic health-status measure providing information for nine different aspects of health status: Physical Functioning, Role Physical, Bodily Pain, General Health, Vitality, Social Functioning, Role Emotional, Mental Health, and Reported Health Transition. Higher scores indicate a better health state.

#### *Positive and Negative Affect Scale (PANAS)*

PANAS<sup>[11]</sup> is a self-evaluation scale and provides reliable and largely independent measures of Positive Affect (PA) and Negative Affect (NA), regardless of the subject population studied or the time frame and response format used. PA—but not NA—is related to social activity, exercise, and satisfaction and to the frequency of pleasant events and is related to diurnal variation. NA—but not PA—is related to self-reported stress, (poor) coping, and frequency of unpleasant events. Low PA and high NA are major distinguishing features of depression and anxiety, respectively. NA is largely unrelated to actual health status. Health complaints are as strongly related to intra-individual fluctuation in PA as in NA.

### **Recruiting**

The subjects had to be over the age of eighteen and diagnosed with TBI. The injury had to be older than two years, and the subjects had all been admitted to the Department for rehabilitation at the hospital. Inclusion criteria were: diagnosed cognitive problems following TBI, and cognitive functioning agreeable with the use of the chosen instruments. The exclusion criteria were: deteriorating cognitive conditions, diagnosed epilepsy or other seizure disorders, psychiatric conditions, substance abuse (drugs and alcohol), or lack of the ability to speak.

### **Design**

The study used a within-subjects, repeated-measures design to assess the effects of binaural beats during the test period. Assessments were carried out before and after listening to Hemi-

Sync products for a minimum of five times a week over a period of three months. The assessments were administered in the participants' homes. Participants were given five CDs each, four for improved attention and concentration (METAMUSIC *Remembrance*, *Einstein's Dream*, *Baroque Garden*, and also *Concentration*) and one for relaxation/falling asleep (METAMUSIC *Sleeping through the Rain*). They were free to choose any of the five selections they were given, and they listened through stereo headphones. They all wrote a daily "listening log" with information about what CDs they listened to, what time of the day they listened, activity during listening, and any other comments.

## **Ethics**

This project was approved by the Regional Office for Ethical Advice, Regional Committee for Medical Research Ethics, Health Region South.

## **Results**

Of the six participants, two showed few or no changes on any of the measures. Also, they had no comments on the experience that indicated noticeable changes in their lives. They are therefore omitted from the case descriptions. They were the two oldest male participants, ages fifty-two and seventy-five. They did listen to their CDs the agreed-on number of times.

The four participants whose cases are described below all listened to their CDs more than the agreed-on times during the study.

*Case 1:* A young man, age twenty-five, was injured as a child in a traffic accident. He used the CDs mainly to rest/sleep.

*Findings:* The AMPS showed an increase of 0.2 logits on motor skills from just under cutoff to just above cutoff. The process skills had an increase of 1.3 logits from 0.2 under cutoff to 1.1 above cutoff. This last increase is statistically and clinically significant. The PANAS showed an increase of 7 on the positive scale and a decrease of 7 in the negative scale. This should indicate a more satisfactory social life and less self-reported stress. The SF-36 showed an increase in five measures: Mental Health (+3), Vitality (+5), Pain (+1), General Health (+3), and Social Functioning (+4). Physical Functioning was reduced (-1), probably because he had a back problem the last month of the project. Role Physical, Role Emotional, and Health Transition were unchanged.

In summary of the findings, we see a significant increase on AMPS process skills and some increase on AMPS motor skills. Both measures on the PANAS are positive and SF-36 shows an increase on five of the measures, while four remain unchanged.

**Case 2:** A young woman, age eighteen, had a bicycle accident three years ago. She used the CDs to fall asleep.

*Findings:* The AMPS showed small changes; motor skills went down 0.1 logits from 0.4 to 0.5 under cutoff and process skills went up 0.3 logits from just under cutoff to just above cutoff. Neither of these figures is statistically significant. The PANAS scales showed an increase of 22 on PA, indicating an improved social situation. The NA increased 3 points, indicating a small increase in self-reported stress. The SF-36 showed an increase on five of nine measures: Mental Health (+3), Vitality (+2), Pain (+1.6), General Health (+6.4), and Role Physical (+1). The other functions, Social Functioning, Physical Functioning, Role Emotional, and Health Transition, remained unchanged.

In summary of the findings, we see a slight improvement in AMPS process, a big improvement on PA, and an increase in five measures on the SF-36. Also AMPS motor skills were slightly reduced and NA went up slightly. Four measures on the SF-36 remained unchanged.

**Case 3:** A woman, age forty-five with a husband and three children, was in a car accident eight years ago. It was several years before she was diagnosed with TBI. She had no particular listening pattern.

*Findings:* The AMPS did not show any changes. She scored well over cutoff on both tests.

The PANAS scale showed an increase on PA of +7, indicating improved social life and an increase in frequency of pleasant events. NA was reduced with -7 points, indicating less self-reported stress and a decrease of unpleasant events. The SF-36 showed an increase in six of nine areas: Mental Health (+1), Vitality (+10), Pain (+2.1), Physical Functioning (+3), Role Physical (+2), and Health Transition (+39). The other functions, General Health, Social Functioning, and Role Emotional, remained unchanged.

In summary of the findings, we see a positive increase on both measures on PANAS and an increase on six of the SF-36 measures. The AMPS and three of the measures on the SF-36 remained unchanged.

**Case 4:** A woman, age forty, lived with her husband and daughter. Seven years ago her heart stopped and she suffered a TBI as a result. She had no particular listening pattern.

*Findings:* The AMPS showed an increase of 0.6 logits on Motor Skills from 1.7 to 1.1 under cutoff. This is statistically and clinically significant. Process Skills showed an increase of 0.2 logits under cutoff. This is not statistically or clinically significant. The PANAS showed a decrease of -11 on PA, indicating reduced satisfaction with social life and a decrease in frequency of pleasant events. Her NA showed a decrease of -6, indicating less self-reported stress and a decrease in frequency of unpleasant events. The SF-36 showed an increase in

four of nine measures: Vitality (+1), Pain (+1.9), General Health (+2), and Social Functioning (+3). Mental Health decreased (-1), as did Health Transition (-16). Measures of Physical Functioning, Role Physical Role, and Role Emotional remained unchanged.

In summary of the findings, we see a significant improvement on AMPS motor skills and a slight improvement on AMPS process skills. The patient had reduced NA, and SF-36 improved on four measures. She had negative reduction on PA and reduction on two measures on SF-36, while three measures on the SF-36 remained unchanged.

## **Discussion**

Owing to an increase in traffic accidents, brain injuries are a growing health problem. Recovery and rehabilitation are often lifelong and expensive in time, effort, and money. In this rehabilitation process there is a lack of suitable noninvasive methods that can be administered by the patient him- or herself.

Hemispheric synchronization by binaural-beat auditory stimulation (Hemi-Sync) is designed to alter arousal levels and heighten awareness and performance while creating a relaxed state. Hemi-Sync has been used for about thirty years in connection with many different diagnostic groups, as well as with healthy persons.

The object of this project was to assess—for the first time— the feasibility and efficacy of using binaural auditory beats in a sample of individuals who have suffered TBI, with the goal of improving self-esteem, quality of life, and function in daily living. According to the data from the instruments used and the feedback from the participants and their families, the results are promising.

After three months of regular listening, four of six patients reported improved social functioning. The two young respondents reported improved sleep and the two older women reported increased vitality and energy. For all four their whole life situation seems to have changed for the better.

Case 1 reported after the project that he now sleeps better, he is less restless, feels calmer, has an improved social life, and manages a steady 50 percent employment. Improved sleep may be a key factor in the overall improvement in his life.

Case 2 was preparing for an exam during the project, as well as planning her further school career and planning to move away from home. She completed her exam successfully and is now pursuing her career. She is now living on her own. Improved sleep may be an important factor in her improved functioning.

Case 3 has a husband who did not want to give the CDs back to the investigator. He thought his wife had more energy, had more of a temper, and reacted more strongly and quickly during the project. The woman herself says that she did not notice these changes. What she did notice was an increase in energy and feeling more alert and present.

Case 4 experienced stress during the project, as she was worried about her work rehabilitation. Work rehabilitation agreements were made shortly before the project finished, and after that she showed unexpected improvements both in her ADL and her work performance. In spring 2002 she was estimated to need two hours additional municipal homeservice per week. After the project (autumn 2002) her need for additional help was reduced to thirty minutes. In the work rehabilitation she is now evaluated to be able to qualify for paid work within a couple of years. During her previous years of rehabilitation, paid work was never mentioned as a realistic goal.

More studies with binaural auditory beats should be done in patients with old TBI and perhaps also in the post-acute recovery after TBI. Prospective controlled trials are necessary to predict efficacy.

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Signe Klepp is an occupational therapy specialist in Kristiansand, Norway, with ten years of experience in rehabilitating people with traumatic brain injury (TBI). She is also a trained communicologist and runs her own firm, giving specialized health education. Communicology correlates vast amounts of information, knowledge, and concepts with the goal of identifying "master keys," the active ingredients in communication and change. In this paper, Signe examines whether Hemi-Sync can make a difference in the long-term rehabilitation of people with old TBI.

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